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A Business and Legislative Perspective of V2X and Mobility Applications in 5G Networks

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ABSTRACT Vehicle-to-everything (V2X) communication is a powerful concept that not only ensures public safety (*e.g.,* by avoiding road accidents) but also offers many economic benefits (*e.g.,* by optimizing the macroscopic behavior of the traffic across an area). On the one hand, V2X communication brings new business opportunities for many stakeholders, such as vehicle manufacturers, retailers, Mobile Network Operators (MNOs), V2X service providers, and governments. On the other hand, the convergence of these stakeholders to a common platform possesses many technical and business challenges. In this article, we identify the issues and challenges faced by V2X communications, while focusing on the business models. We propose different solutions to potentially resolve the identified challenges in the framework of 5G networks and propose a high-level hierarchy of a potential business model for a 5G-based V2X ecosystem. Moreover, we provide a concise overview of the legislative status of V2X communications across different regions in the world.

INDEX TERMS 5G, V2X communications, marketplace, business model, public safety, optimization.

I. INTRODUCTION

The cooperation between vehicles and intelligent mobility is one of the most powerful concepts of Intelligent Transport Systems (ITS). This cooperation requires intelligent communication systems for wireless data exchange not only between the vehicles but also with other entities such as motorcyclists, cyclists, pedestrians, and communication infrastructures. This type of communication of a vehicle with its surrounding is commonly termed, in literature, as Vehicle-to-everything (V2X) communications.

V2X virtually connects a vehicle on the road with almost everything in its proximity and potentially changes the landscape of current transportation systems. For instance, some researchers believe that connecting vehicles with everything will help to optimize the traffic across an entire city [1]. With this optimization, the status of traffic lights and queues can be shared with the drivers and pedestrians via their smartphones [1]. The potential benefits of such an optimized traffic network include, but are not limited to, reduced traffic congestion in the city, additional traveler services, reduced CO_2 emission in the environment, reduced wastage of fuel, and consequently lesser economic burden. For instance, the economic loss due to traffic congestion in the US alone was about \$121 billion during the year 2011 [1].

V2X communication is mainly divided into four types: Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), Vehicle-to-Network (V2N), and Vehicle-to-Pedestrian (V2P). Figure 1 illustrates each of the aforementioned types.

- **V2V:** V2V is the direct communication between vehicles for exchanging information about location, velocity, and direction of vehicles to avoid accidents.
- **V2I:** V2I is the communication between a vehicle and an access network node, such as a Road Side Unit (RSU) or a Next Generation Node B (gNB).
- **V2N:** V2N is the communication between a vehicle and a V2X application service provider, such as a traffic management entity.

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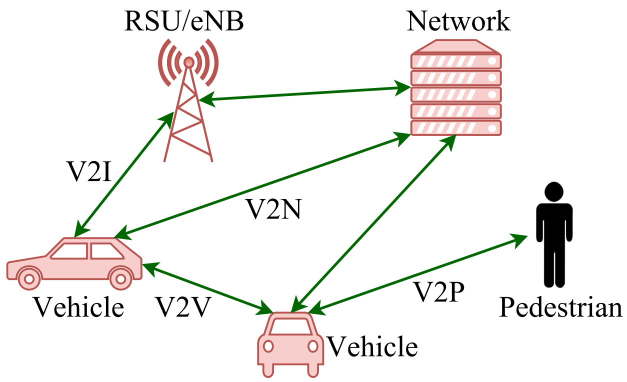


FIGURE 1. V2X communication types: The vehicle not only communicates with other vehicles (V2V) but also with its surroundings, such as pedestrians (V2P), the infrastructure (V2I), and the network (V2N).

- **V2P:** V2P is the communication between vehicles and pedestrians.

Many aspects of the V2X ecosystem have been separately analyzed in the literature [2]. However, the business models and the legal issues are the least addressed topics in the V2X literature. Whereas, legal and business aspects play a vital role to integrate a technology into a society. For instance, a decision to use 5G or its competitors (see Section II for details) for V2X communications in a region will not only depend on the technology merits of a particular technology but also its ability to accommodate new business trends. This ability, coupled with the standardization efforts, will lead to reforms in the legislation to favor or disfavor a particular technology for V2X. This article provides an overview of legal status of V2X communications across many regions of the world and identifies potential issues and challenges in defining an efficient business model for a complete V2X ecosystem including ITS. Furthermore, we propose different solutions to potentially resolve these issues and challenges. Moreover, we discuss the merits and demerits of different competing technologies for V2X communications and stress that 5G provides better business opportunities for stakeholders in the V2X ecosystem. Moreover, we discuss the limitations of the current business model of a V2X system and provide a high-level business hierarchy of 5G-based future V2X systems.

To the best of our knowledge based on the open literature, this is the first work that focuses on identifying business and legal challenges of V2X communications. Table 1 summarizes the state-of-art of recent surveys in the field of V2X communication. These surveys cover a broad range of works in the area of V2X communications. However, it is evident from the table that most of these articles cover communication and security aspects of V2X communication and only a few of them partially cover business aspects. Hence, highlighting the legislative and business challenges of V2X communications remains an open area of research.

The rest of the article is organized as follows. Section II provides the recent status of V2X standardization. Section III provides a summary of legal status of V2X communications across many regions of the world. V2X communication use case scenarios are discussed in Section IV. Section V identifies potential problems of V2X and shares their respective solutions with a proposed business model. Finally, Section VI concludes the article.

TABLE 1. A summary of the V2X literature. A few works focus on the business and legislative perspective of V2X.

Reference	Communication	Security	Legislation	Business
[3]	✓	✓	✗	✗
[2]	✓	Partially	✗	✗
[4]	✓	✓	✗	✗
[5]	Partially	✓	✗	✗
[6]	✓	✗	✗	✗
[7]	✓	✗	✗	✗
[8]	✓	✗	✗	Partially

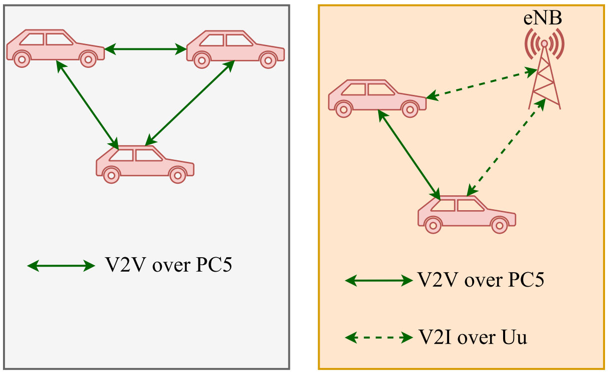
II. STANDARDIZATION EFFORTS

In this section, we summarize recent advances in the standardization of two competing standards for V2X communications including Cellular V2X (C-V2X), *a.k.a.* LTE-Vehicle (LTE-V) [9] and Wireless Access in the Vehicular Environment (WAVE) [10]. An initial version of C-V2X has been standardized by the 3rd Generation Partnership Project (3GPP) in release 14, while WAVE is standardized by IEEE and is basically constituted by two standards including (i) IEEE 802.11p for the physical and Medium Access Control (MAC) layer and (ii) IEEE 1609 for security and upper layer features (*e.g.,* providing addressing and routing services) of V2X communication. Both C-V2X and IEEE 802.11p are designed to operate in the Intelligent Transport System (ITS) spectrum, *i.e.,* 5.9 GHz.

V2V in 3GPP is based on D2D communications defined as Proximity Services (ProSe) in LTE releases 12 and 13. In particular, ProSe is enhanced for vehicular use cases, addressing high-speed (up to 250 Km/h) and high density of nodes (thousands of nodes). Two high-level configurations of V2V communications defined in LTE release 14 are given in Figure 2, which are *distributed scheduling* and *gNB scheduling* (The term *gNB* is the evolution of the term *eNB* in 5G. However, 3GPP release 14 uses the term eNB).

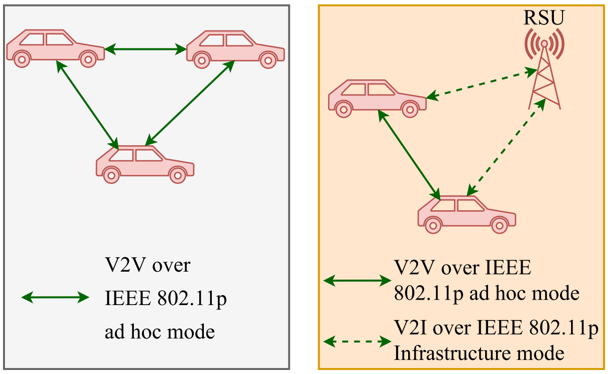
In the *distributed scheduling* (Figure 2(a)), the interference management and scheduling of resources are done via utilizing distributed algorithms. The vehicles communicate over PC5 interface; where, PC5, *a.k.a.an LTE side link*, is a new interface defined for ProSe in LTE releases 12 and 13. In the *gNB scheduling* (Figure 2(b)), the vehicles still communicate directly though the control remains with the gNB, which is responsible for resource allocation and interference management. The control is provided over U_u interface, which is a conventional LTE interface utilized for communication between User Equipment (UE) and gNB.

The other competing standard, *i.e.,* WAVE, is mainly based on IEEE 802.11, defined for Wireless Local Area Network (WLAN). More specifically, IEEE 802.11p is defined for V2V communication at physical and MAC layers. In order to observe the high-level difference between C-V2X



(a) Distributed scheduling (b) gNB scheduling

FIGURE 2. The configurations of V2X communications in release 14 of 3GPP.



(a) Distributed mode (b) Infrastructure mode

FIGURE 3. The configurations of V2X communications in IEEE 802.11p.

TABLE 2. A comparison between WAVE (IEEE 802.11p based), C-V2X (LTE rel. 14), and future 5G technologies for V2X communications.

Parameters	WAVE	C-V2X (LTE Rel. 14)	Future 5G
Currently available technology	Yes	Yes	No
Field trials (+10 years)	Yes	No	No
Applications	V2V, V21	V2V, V2I, V2N	V2V, V2I, V2N
Latency	5 ms	20 ms	<5 ms
Data rate	3-27 Mbps	150 Mbps	10 Gbps
Multimedia and cloud services support	No	Yes	Yes

and WAVE, the aforementioned configurations for C-V2V are presented in Figure 3 for WAVE protocols. In the distributed mode (Figure 3(a)), the vehicles directly communicate with each other using IEEE 802.11p, while in the central mode (Figure 3(b)), the vehicles communicate with the help of Road Side Unit (RSU) using 802.11p in the infrastructure mode. The time synchronization between vehicles in the distributed mode is mainly provided by the Global Navigation Satellite System (GNSS).

A high-level comparison between C-V2X and WAVE is presented in Table 2 [11]. From Table 2, we can note that IEEE 802.11p is quite an old technology with more than 10 years of field trials. However, it lags behind in many features as compared to C-V2X standardized in release 14 of 3GPP. For instance, IEEE 802.11p does not provide any support for multimedia and cloud services to V2X communications, while the other two do. As there is no support for cloud services, the use cases and applications supported by IEEE 802.11p are less than once provided by C-V2X or 5G. More importantly, 5G promises to outperform the other two technologies in all respects.

Figure 4 illustrates the timeline of the standardization efforts happening across 3GPP for C-V2X communication. The timeline represents the C-V2X features standardized in each release with the industry progress in designing the required chipset and equipment. The rectangular blocks represent the features in each release while the horizontal bars below represent the industry's progress [12].

III. LEGAL STATUS OF V2X COMMUNICATIONS ACROSS DIFFERENT REGIONS

A. UNITED STATES

In the United States (US), the Department of Transportation and National Highway Traffic Safety (NHTSA) has enforced the IEEE 802.11p standard for Vehicle-to-Vehicle (V2V) communications among all new vehicles [13]. This mandate can impact the V2X market in the US. However, cellular network providers, automotive companies, and chip suppliers (*e.g.,* Qualcomm) have recently requested NHTSA to also consider cellular-based technologies, thereby making the mandate being technology neutral.

B. EUROPEAN UNION

In the European Union (EU), the European Commission has approved regulations to include emergency Call (eCall) in all new cars sold in the EU after April 2018.[1] eCall is an European initiative, which offers quick assistance to the vehicles involved in accidents, by automatically informing E112, an emergency telephone number across Europe, about the incident. This implies that all the new cars will be equipped with a cellular modem. These regulations pave the way for opening new doors in cellular based V2X communications across the EU. A prototype of the solution has already been tested with General Packet Radio Service (GPRS) and in-band signaling over cellular networks. Furthermore, the European Parliamentary Research Service (EPRS) has provided a briefing on regulatory and legal framework for automated vehicles [14]. Moreover, a number of amendments have been proposed to the *Vienna Convention on Road Traffic* in order to support driverless cars.

C. OTHER COUNTRIES

1) UK

Recently, the United Kingdom (UK) Parliament has introduced the Vehicle Technology and Aviation Bill that proposes to rely on a fault-based approach combined with the existing

[1] https://ec.europa.eu/digital-single-market/en/news/ecall-all-new-cars-april-2018

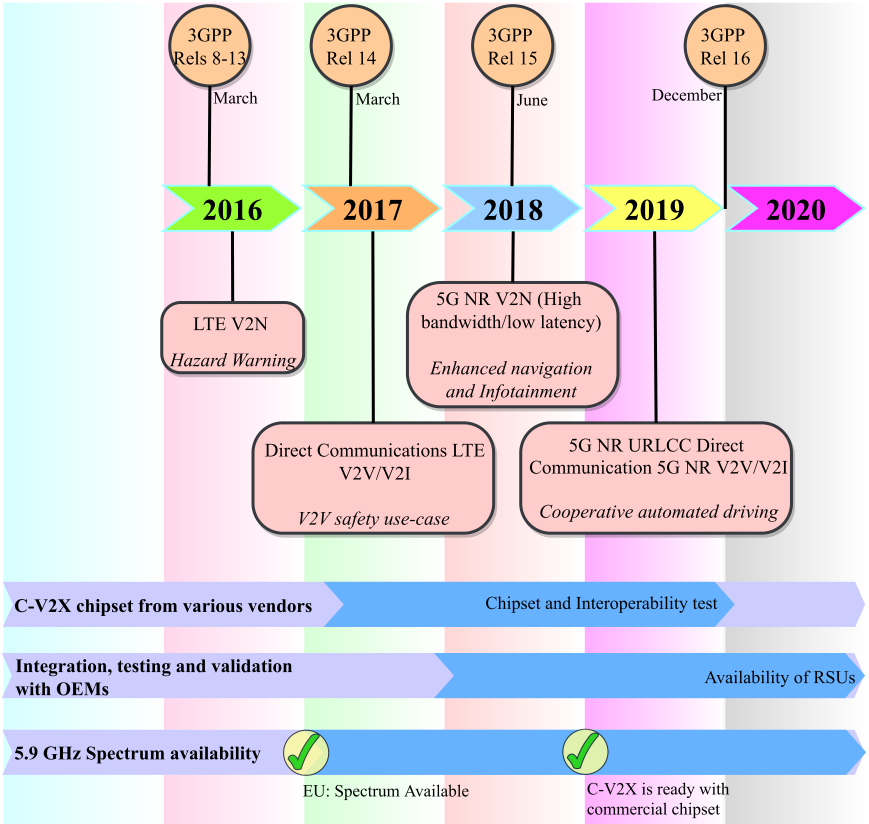


FIGURE 4. Standardization efforts of C-V2X across 3GPP.

product liability law as the basis for liability of autonomous vehicles [15]. The testing of the autonomous vehicles has become legal across the UK after 2015 [16]. In addition, a joint policy unit has recently been created between the department of transport, the Department of Business, Innovation and Skills, and the Center for Connected and Autonomous Vehicles in order to minimize regulatory and administrative burden while allowing the industry to keep going on to remove the potential barriers in the way of ITS.

2) JAPAN

Currently, in Japan, all cars are required to be controlled by a real person [17], requiring automotive industries to have special permission to perform road tests. The rules placed by the National Police Agency requires that all the tests on public roads must be conducted with a driver in the vehicle. Moreover, other restrictive rules include limiting autonomous passing to expressways and holding a human driver accountable for any accident, thereby requiring the installation of a device designed to prevent operators from falling asleep or looking away. The device could utilize a sensor to judge an operator's condition. However, in 2015, the Japanese government issued guidelines to establish semi-autonomous features in cars by 2020 and launch fully autonomous vehicles by 2025.

3) CHINA

In December 2016, the Ministry of Industry and Information Technology (MIIT) and China's Society of Automotive Engineers issued a draft plan for autonomous vehicles, where partially autonomous cars will account for 50% of the sales by 2020, highly automated cars account will account for 15% of the sales by 2025, and fully autonomous vehicles will account for 10% of sales by 2030 [18]. However, this document falls short in establishing a unified standard for V2V communications and surrounding infrastructure, *i.e.,* Vehicle-to-Infrastructure (V2I), which is very crucial for the successful deployment of autonomous vehicles.

The mass production of vehicles with "conditional" self-driving capabilities is planned by 2025 according to the development plan released in February 2020, by the country's National Development and Reform Commission (NDRC). According to the Society of Automotive Engineers (SAE), "Conditional" driving automation refers to Level 3 technology that allows a car to drive itself only under the circumstances in which a human driver is ready to take control in case of an emergency (to see the details of level 3 technology, please see Figure 5). Thus this new target is a downgrade from what was set in 2016, the main reasons being several technological challenges faced by autonomous vehicle developers to ensure 100% safety for driverless cars.

4) INDIA AND AUSTRALIA

The work in [19] points out the legislative and regulatory hurdles in India's driverless car future, making it uncertain. For instance, Geospatial Information Regulation Bill (2016) prescribes hefty penalties and jail sentences for persons in breach of it. On the other hand, Google's driverless car, for instance, relies on information from the Global Positioning System (GPS) satellites. If such a bill becomes a law, autonomous vehicles may be faced with unnecessary regulatory hurdles, which may dissuade investors. In Australia [19], on the other hand, the government has announced that it would draft legislation for autonomous vehicles within the next 18 months.

IV. USE CASE SCENARIOS

V2X communication is not just for the vehicles' safety on the roads but it also enables many other use cases and applications summarized in Table 3. These use cases include, but are not limited to, safety of road users, information and entertainment (infotainment) services, platooning, remote monitoring and maintenance, data collection for insurance, and the driver assistance. Safety on the road is mainly ensured by the communication among the vehicles and other road users to avoid potential collisions and stop in case of emergency such as an accident on the road. By virtue of communication among sensors empowered vehicles (that avoids accidents between them), vehicles can platoon themselves half a meter apart or less, while running on the road or waiting for a red traffic signal to stretch the road capacity and infrastructure.

There are many use case scenarios when the communication of vehicles with their surroundings enables various Location-Based Services (LBS). For instance, a vehicle traveling on the road may receive the promotions regarding free oil change, cheap cleaning services, and the price of fuel before it reaches the fuel station. In case of electric cars, an estimation of battery consumption in traveling from the origin to the destination can be communicated with the driver, keeping in view the travel distance, current traffic conditions, wait time on red lights, and the charging stations on the routes, among others. Moreover, the vehicles can receive promotions from various service providers nearby, such as theaters, cinemas, cafeterias, and restaurants while in the area. This will be more beneficial for driver-less and fully autonomous vehicles so the driver can browse through the saved promotions she uses her autonomous vehicle at a later stage.

Besides the aforementioned scenarios, V2X communications can potentially increase the security across the city by detecting, say toll evaders, driving on bus-only lane, red light crossing, and over speeding. These scenarios require communications between the control center and/or among camera/sensors to rightly detect any misbehaving vehicle. The cellular network can be a natural solution for this communication due to its vast coverage. The other use cases of V2X and smart transport system include fleet management and PayAsYouDrive insurance that can utilize the cellular network to transmit the driving pattern and vehicle health to insurance companies and/or car rentals. Similarly, advertising traffic information through social media and displaying possible congestions ahead on the vehicle's digital panel can reduce the cost of big electronic displays on the roads. All these applications are equally beneficial to transport authorities and Mobile Network Operators (MNOs) within business and economic perspectives, to consumers within fuel consumption and time to arrive at the destination perspectives, and to the climate by emitting less CO_2.

Table 3 presents a one-to-one mapping of different V2X use cases to technical requirements of the network. It is important to note that all the presented use cases in Table 3 demand different requirements on the network. For instance, ensuring vehicle's safety and avoiding accidents on the road requires very low latency and extremely reliable network but it does not require very high throughput. Similarly, infotainment services require higher throughput with the far relaxed requirement of latency and reliability.

It is important to note that all aforementioned use cases are not for fully autonomous vehicles but provide an evolution path towards it. Some of the use cases may already be possible with the current available technology. For instance, direct communication between vehicles is already possible using IEEE 802.11p. However, they provide a short range V2V communication possibilities only, which may not always be the case. The fully autonomous vehicles extend beyond the V2V, requiring other communication paradigms of V2X such as V2I, V2N, and V2P. C-V2X may seem a viable solution for these communication paradigms but it does not completely achieve the technical requirements of many use cases mentioned in Table 3, for instance, more demanding safety requirements [24]. However, 5G will provide improvements to C-V2X standard in order to pave the way towards fully autonomous vehicles.

V. ISSUES, CHALLENGES, AND POSSIBLE SOLUTIONS

Apart from the aforementioned technical challenges, V2X communication poses various business challenges. V2X communication is a complex ecosystem wherein a vehicle is not only connected with almost everything in its surrounding but also to cloud service providers and cellular networks for many applications. This ecosystem includes many stakeholders such as: (i) MNOs, (ii) vehicle manufacturers, (iii) pedestrians on the road, (iv) Internet-of-Things (IoT) service providers, (v) government agencies responsible for installing and maintaining road infrastructure such as traffic lights, (vi) public safety agencies for crime detection, (vii) cloud service providers that use big data algorithms to observe the macroscopic behavior of the city traffic, (viii) insurance and car rental companies, (ix) the driver itself, and (x) the other companies such as theaters and restaurants for V2X based LBS.

All these companies, agencies, and government departments work independently with their own business models

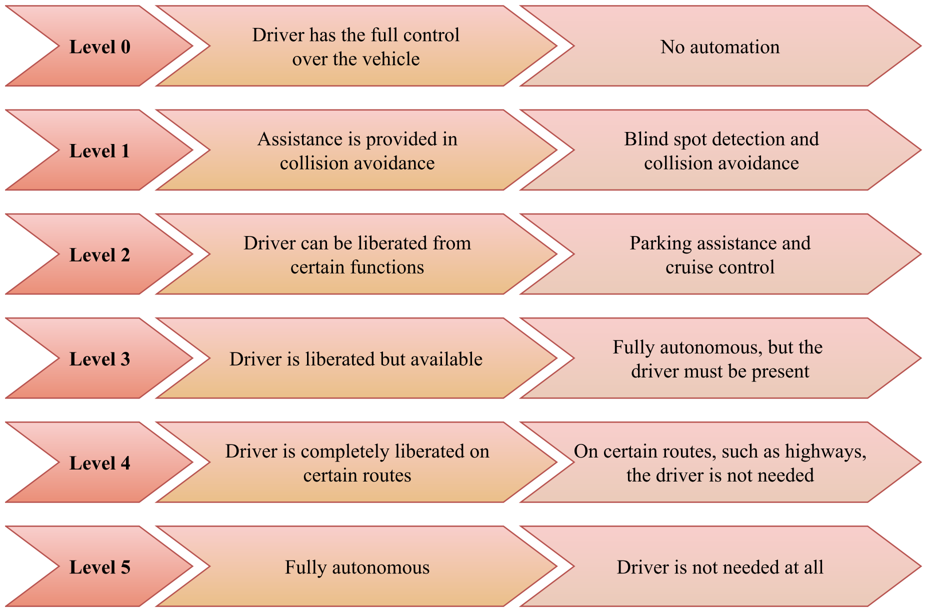


FIGURE 5. Autonomous levels of V2X communications defined by TSA [25].

that work within the boundaries of their companies. Gluing all these stakeholders together is not only a technical challenge but also a business provocation, which requires a model that works in favor of all the stakeholders by providing subsequent incentives to everyone. This requires innovative solutions to implement the concept *who will get what?* in response to the resources provided by any stakeholder to the V2X ecosystem.

Economically, It would be interesting to answer the following questions prior to proposing a business model for V2X communications.

- Who will pay the connection cost? Will it come from the consumers, *i.e.,* the vehicle owners who are the end users of V2X or the Original Equipment Manufacturers (OEMs) that put the connectivity options in the vehicles? Or will it be a contribution from both?
- Who will invest in the infrastructure? Will the investment come from MNOs or automobile industry or governments that want to facilitate their citizens?
- Will there be an opportunity for joint investment or risk sharing between MNOs and automobile industry for the network deployment costs?
- Will there be an opportunity for per-service charge, based on the network resources a V2X service utilizes?
- What will be the role of insurance companies in the V2X ecosystems?
- For multi-national unions, such as EU and Gulf Cooperation Council (GCC), *etc.*, will there be a bilateral agreement between MNOs and automobile industry for pan-union services or there will be intermediate bodies that will establish deals between MNOs and automobile industries?

It is important to note that the large-scale deployment of a fully autonomous vehicle is yet to be introduced. However, some functions of autonomous vehicles already exist in many vehicles. Indeed, the US Transportation Security Administration (TSA) has categorized the autonomous vehicles into different levels based on the driver automation they provide [25]. This categorization is provided in Figure 5. While discussing business models of V2X communications, it is imperative to consider the levels of driver automation. A business model that works for level 2 or 3 may be different than the one for levels 4 or 5.

A. ISSUES AND CHALLENGES

In what follows, we identify some issues and challenges in defining business models for a V2X ecosystem.

1) DIVERSITY IN USE CASES

Diversity in use cases, applications, and stakeholders is the biggest technical and business challenge for V2X ecosystem. For instance, a simple scenario of getting advertisements from a nearby fuel station may involve MNO, the driver, fuel station, and the cloud service provider. Cloud service provider uses MNO's resources to send the advertisements to the vehicle, when it detects that the vehicle is geographically near to the fuel station. Again, MNO is utilized to connect fuel station to cloud service provider in order to update the promotions and offerings. Consequently, MNO may work as a glue to integrate all stakeholders in a business model. In addition, different use cases (Table 3) require divergent network resources, which should be billed differently.

2) INCENTIVE MANAGEMENT

In some scenarios, such as accident avoidance, if a MNO is assisting in avoiding accidents on the roads by providing its network resources, it must be granted some incentives in return. However, *who will provide these incentives?* is an

TABLE 3. Use cases of V2X communications.

Use Cases	Description	Technical Requirements				
		Latency	Throughput	Mobility	Connection Density	Reliability
Safety of road users [20]	Collision warning and avoidance Emergency warning and stop	< 5ms	L	> 200 km/h	$> 10{,}000$/km^2	$> 99.99\%$
Platooning [21]	Reduced distance between vehicles	< 5ms	L	> 200 km/h	L	$> 99.99\%$
Data collection [22]	Collection of huge amount of telemetry data for new insurance models	L	> 10 Mbps	> 200 km/h	$> 10{,}000$/km^2	L
Driver assistance [21]	See through the front vehicle	< 5ms	> 10 Mbps	> 200 km/h	L	$> 99.99\%$
Infotainment services [2]	Information and entertainment services for the driver	L	> 10 Mbps	> 200 km/h	$> 10{,}000$/km^2	L
Remote monitoring and diagnostics	Improving the efficiency of the vehicle	L	L	L	L	L
Location-based services [2]	Advertisements from different sellers	L	L	- RGNB VB-	L	
Security [23]	Detecting traffic rules violations	L	L	-	-	L

L = Less stringent

open question. For instance, in case of an autonomous vehicle, will it be the owner of the vehicle or the vehicle's manufacturer or the government agencies that always try to minimize the road accidents by providing suitable infrastructure to its residents. The same question holds for each use case of V2X, particularly in the case of fully autonomous vehicles.

3) LACK OF COORDINATION

An issue in defining business models for V2X communication ecosystem is the lack of coordination and cooperation between different departments, agencies, and companies. A common platform is needed where all the stakeholders, including government agencies and standardization bodies, can meet and agree upon the technical and business requirements of future V2X communications. In this coordination, the participation of the legislative body is very important as their decisions can complete the business landscape of V2X communications in a region. For instance, the enforcement of IEEE 802.11p standard for V2V communications in the US will affect the future of C-V2X in the States. An effort to establish this common platform has recently been initiated as 5G Automotive Association (5GAA).[2]

4) INSURANCE MANAGEMENT

Another issue is the business with insurance companies for completely autonomous vehicles. For instance, in the case of an accident by an autonomous vehicle, *who will be held accountable: the owner or the vehicle manufacturer?* Moreover, what will be the role of driving licensing authorities for fully autonomous vehicles? Can they be sold to customers without any driving license? These questions need careful consideration in V2X business models [26].

B. POSSIBLE SOLUTIONS

It is important to note that the current business model (see Figure 6) is not able to address the aforementioned challenges. It is possible to integrate V2X to current business

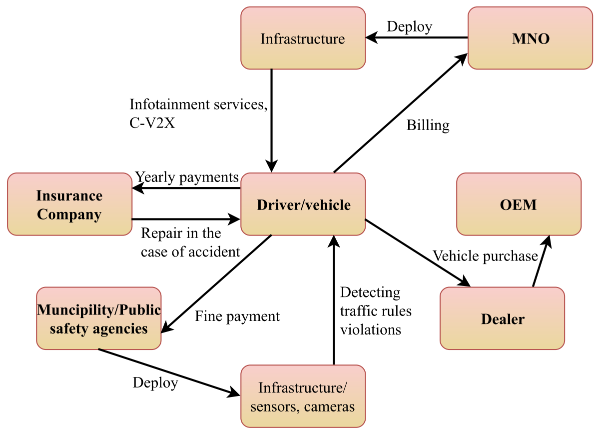


FIGURE 6. Current picture of the business model of automotive industry and MNOs: The business model is quite limited in terms of practicability of many use cases of V2X communications, especially the autonomous level of 3 and above.

model of MNO but all the use cases of V2X, presented in Table 3, may not be practical. Furthermore, only the use cases of autonomous level 3 may be possible using the current C-V2X standard. Moreover, in the current business models, there is no option to charge a customer based on the network resources s/he utilizes. It can be observed from Figure 6 that currently, there is no direct relationship between MNOs and automotive industry, which prevents the realization of many use cases of autonomous vehicles. Keeping in view the limitations of current cellular systems, following considerations may be useful while working towards the business model of V2X communications.

1) 5G ORIENTED SOLUTIONS

As MNO is mainly responsible for the communication between many stakeholders, it can act as a marketplace for these stakeholders as well. More specifically, a MNO may work as a glue to integrate these stakeholders into a business model. For instance, in a LBS scenario, a fuel station deals independently with the cloud service provider for a specific application and MNO for their network resources.

[2] http://5gaa.org

Similarly, a MNO can work together with the cloud service providers, the fuel station, and the end user (autonomous vehicle/driver) to provide end-to-end business solutions to all stakeholders involved.

Cellular networks are already proposed to replace many legacy systems in public safety, such as Land Mobile Radio (LMR) and Professional Mobile Radio (PMR). First Responder Network Authority (FirstNet), an initiative in the US to operate and maintain the first nationwide inter-operable broadband wireless network for public safety, is a recent example of this transition [27]. The same can be applied to V2X communications as well.

2) TECHNOLOGY NEUTRAL SOLUTIONS

Technology neutrality is one of the most important aspects within V2X communications for an efficient and effective business model. The business model must include all present and upcoming V2X standards such as IEEE 802.11p, C-V2X (LTE release 14), and 5G. The legislative enforcement in the EU supports the concept of technology neutrality in V2X communications.

3) NETWORK VIRTUALIZATION

Software-Defined Networking (SDN) and Network Function Virtualization (NFV) based solutions for V2X communications in 5G networks will not only fulfill the technical requirements of V2X but also support an easy implementation of business models. The virtualization of network resources in 5G using SDN and NFV enables MNOs to virtually modify the network to fulfill the Quality of Service (QoS) requirements of different integrated applications such as V2X. This virtualization of network resources is mainly managed by NFV Orchestrator. The functionalities of same orchestrator can be extended to support the different use cases of V2X communications in terms of business models. The orchestrator must have the ability to virtually adopt the business requirements of different V2X use cases. An overview of the highlighted issues and their prospective solutions are summarized in Figure 7.

Based on the aforementioned solutions, we propose a business model for 5G based V2X services in Figure 8. The business model provides a high-level hierarchy of various organizations and agencies in the V2X ecosystem and their inter-connections. It is important to note that the proposed business model may not be directly applicable to future V2X ecosystem in its current form but a modified version of it can be implemented based on the region and their legislation. For instance, currently in Figure 8, the fine of traffic rules violation goes to driver; however, in the case of fully autonomous vehicles, it might go to OEM, in case the legislation allows to do so. In addition, intermediaries will play a very important role in the business of autonomous vehicles who can make agreements with both MNOs and OEMs and provide seamless services to autonomous vehicles across a region, such as EU or GCC. Moreover, network slicing and virtualization will act as a heart of the V2X ecosystem, which will not only enable many use cases of V2X, such as per service billing

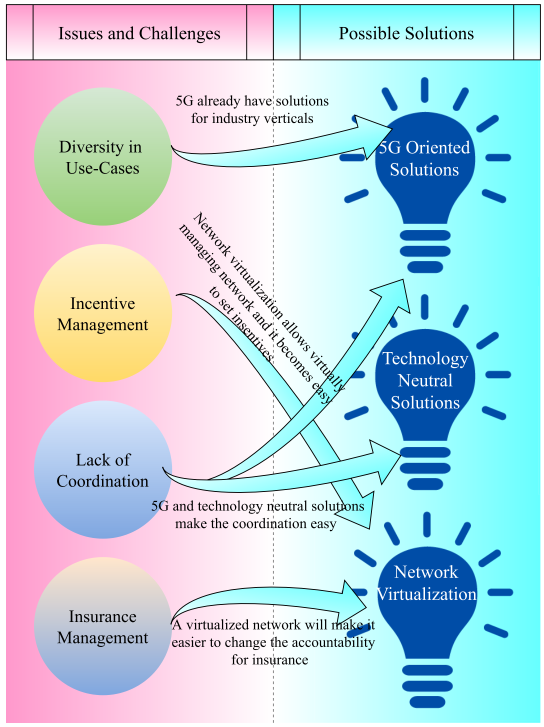


FIGURE 7. A summary of highlighted issues and their potential solutions.

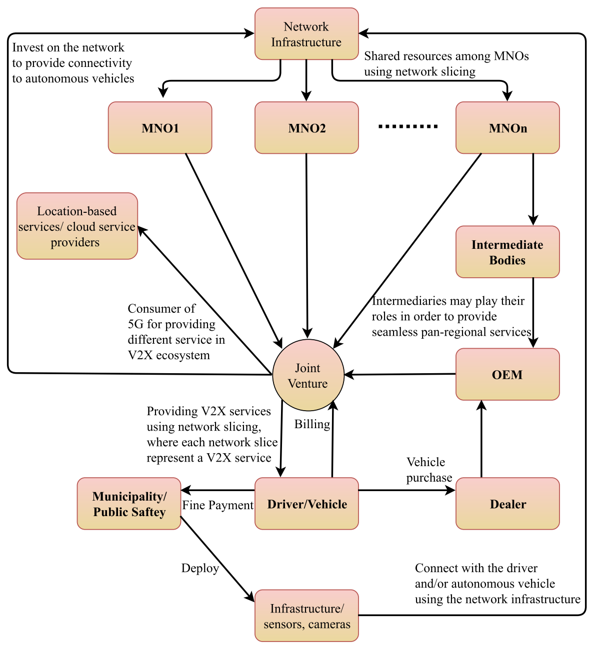


FIGURE 8. A business model for future V2X ecosystem: The future V2X systems will open a room for new startups, intermediaries, and joint ventures between MNOs, OEMs, and intermediaries. Furthermore, SDN/NFV will remain at the heart of the V2X ecosystem.

but will also enable the sharing of network resources among MNOs. This enables a service trade between MNOs built on the top of shared network resources. In fact, a joint venture between MNOs and OEM can be formed to invest in the network resources, wherein cloud service providers can be a consumer of those resources for different LBS in the V2X ecosystem.

VI. CONCLUSION

In this article, we have provided an overview of legal status of V2X communications in different countries and discuss how this legislative framework affects the business landscape of V2X and its penetration into our modern-day society. Furthermore, we have identified the potential issues and challenges faced by V2X industry in terms of efficient business models. Moreover, we have elaborated on the diversity of V2X industry in terms of use case scenarios, applications, and stakeholders involved. Finally, we have proposed various solutions that can help different industries and stakeholders to initiate a common business model based on 5G technologies.

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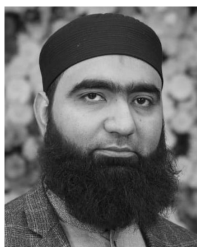

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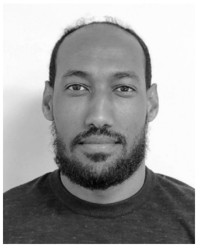

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